Annual average job loss due to disasters

October 14, 2025

1 Packages

[1]:
```
import sys
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import geopandas as gpd
sys.path.append("../../05_code/UB-global-socioeconomic-resilience/code/
 ↪global-unbreakable-model/src")
from unbreakable.misc.helpers import average_over_rp
```

2 Model Data

[2]:
```
# pre-disaster socio-economic data by quintile
quintile_inputs = pd.read_csv("../../05_code/UB-global-socioeconomic-resilience/
 ↪results/simulation_output/0_baseline/model_inputs/scenario__cat_info.csv",␣
 ↪index_col=[0, 1])
quintile_inputs.head(5)
```

[2]:

		income_share	transfers	liquidity	axfin	\
iso3	income_cat					
AGO	0.2	0.037962	0.011672	80.497733	0.034697	
	0.4	0.076923	0.014423	109.740846	0.045700	
	0.6	0.125874	0.011956	159.267237	0.151259	
	0.8	0.203796	0.011173	148.860730	0.190130	
	1.0	0.555445	0.013127	200.587156	0.325150	

		diversified_share	n	c	gamma_SP	k
iso3	income_cat					
AGO	0.2	0.015142	0.2	1393.993628	0.077786	8294.751171
	0.4	0.018993	0.2	2824.671299	0.197712	16742.055488
	0.6	0.027082	0.2	4622.189399	0.461308	27170.207168
	0.8	0.030186	0.2	7483.544741	0.832500	43849.490735
	1.0	0.045641	0.2	20396.327825	3.430694	117606.767306

[3]:
```
# pre-disaster macro-economic data
macro_inputs = pd.read_csv("../../05_code/UB-global-socioeconomic-resilience/
 ↪results/simulation_output/0_baseline/model_inputs/scenario__macro.csv",␣
 ↪index_col=[0])
macro_inputs.head(5)
```

[3]:

iso3	gdp_pc_pp	gni_pc_pp	pop	gini_index	name	region	income_group	prepare_scaleup	finance_pre	borrowing_ability	avg_prod_k	tau_tax	k_priv_share	k_household_share	owner_occupied_share_of_value_added	self_employment	real_est_k_to_va_shares_ratio	rho	income_elasticity_eta
AGO	7344.145379	6254.169531	37885849.0	51.3	Angola	SSA	LMICs	0.561160	0.677083	0.446875	0.171863	0.036948	0.163707	0.477995	0.045119	0.655007	3.705328	0.06	1.5
ALB	18920.894264	18404.637950	2714617.0	29.4	Albania	ECA	UMICs	0.302025	0.740741	0.545370	0.162022	0.187485	0.218850	0.481797	0.065106	0.523627	3.705328	0.06	1.5
ARG	26547.050343	25284.187785	45696159.0	42.4	Argentina	LAC	UMICs	0.486937	0.500000	0.300000	0.307415	0.203801	0.411517	0.343679	0.054230	0.257533	3.705328	0.06	1.5
ARM	20078.784898	18725.711923	3033500.0	27.2	Armenia	ECA	UMICs	0.374010	0.500000	0.441667	0.469678	0.432240	0.177693	0.570949	0.079376	0.609062	3.705328	0.06	1.5
AUS	60082.005787	58522.898774	27204809.0	33.8	Australia	EAP	HICs	0.679070	0.833333	0.916667	0.230998	0.397301	0.499007	0.340918	0.071781	0.130580	3.705328	0.06	1.5

[4]:
```
# hazard protection levels
hazard_protection = pd.read_csv("../../05_code/
↪UB-global-socioeconomic-resilience/results/simulation_output/0_baseline/
↪model_inputs/scenario__hazard_protection.csv", index_col=[0, 1])
hazard_protection.head(5)
```

[4]:
```
                protection        ew
iso3 hazard
AGO  Earthquake    0.000000  0.553528
     Flood        16.283781  0.553528
ALB  Earthquake    0.000000  0.218951
     Flood        15.008699  0.218951
     Tsunami       0.000000  0.218951
```

[5]:
```
# average productivity per worker as the output of the capital used by each␣
↪individual
avg_worker_productivity = quintile_inputs.k * macro_inputs.avg_prod_k
avg_worker_productivity.head(5)
```

[5]:
```
iso3  income_cat
AGO   0.2            1425.557560
      0.4            2877.333300
      0.6            4669.542633
      0.8            7536.087787
      1.0           20212.205613
dtype: float64
```

[6]:
```
# Model simulation results by household
quintile_results = pd.read_csv("../../05_code/
↪UB-global-socioeconomic-resilience/results/simulation_output/0_baseline/
↪simulation_outputs/iah.csv", index_col=[0, 1, 2, 3, 4])
quintile_results.head(5)
```

[6]:
```
                                                helped_cat        fa  v_ew  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a                  helped  0.000178   0.7
                                 a              not_helped  0.000178   0.7
                                 na                 helped  0.000178   0.7
                                 na             not_helped  0.000178   0.7
                     0.4         a                  helped  0.000178   0.7

                                                income_share  transfers  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a                  0.037962   0.011672
                                 a                  0.037962   0.011672
                                 na                 0.037962   0.011672
                                 na                 0.037962   0.011672
```

```
                    0.4        a                0.076923   0.014423

                                                 liquidity     axfin  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a               80.497733  0.034697
                                 a               80.497733  0.034697
                                 na              80.497733  0.034697
                                 na              80.497733  0.034697
                    0.4        a              109.740846  0.045700

                                                diversified_share         n  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a                       0.015142  0.000036
                                 a                       0.015142  0.000000
                                 na                      0.015142  0.000000
                                 na                      0.015142  0.199964
                    0.4        a                       0.018993  0.000036

                                                          c  …  dc_short_term  \
iso3 hazard     rp   income_cat affected_cat                 …
AGO  Earthquake 10.0 0.2        a              1393.993628  …    9882.659005
                                 a              1393.993628  …    9882.659005
                                 na             1393.993628  …       0.000000
                                 na             1393.993628  …       0.000000
                    0.4        a              2824.671299  …   20882.371159

                                                     dC_max  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a              1165.925839
                                 a              1165.925839
                                 na                0.000000
                                 na                0.000000
                    0.4        a              2378.498307

recovery_params  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a              [(0.20658996845759517,
0.13346866827207965), (…
                                 a              [(0.20658996845759517,
0.13346866827207965), (…
                                 na             [(0.20658996845759517,
0.13346866827207965), (…
                                 na             [(0.20658996845759517,
0.13346866827207965), (…
                    0.4        a              [(0.20658996845759517,
0.13346866827207965), (…
```

```
                                                      dk_pub  help_fee  reco_fee  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a              3030.929242       0.0  0.276139
                                 a              3030.929242       0.0  0.276139
                                 na                0.000000       0.0  0.276139
                                 na                0.000000       0.0  0.276139
                     0.4         a              6117.601903       0.0  0.559544

                                                dc_long_term  dW_long_term  \
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a                 80.774094      0.001552
                                 a                 80.774094      0.001552
                                 na                 0.281154      0.000005
                                 na                 0.281154      0.000005
                     0.4         a                110.300634      0.000735

                                                          dc        dw
iso3 hazard     rp   income_cat affected_cat
AGO  Earthquake 10.0 0.2        a                9963.433099  0.281061
                                 a                9963.433099  0.281061
                                 na                  0.281154  0.000005
                                 na                  0.281154  0.000005
                     0.4         a               20992.671793  0.200883

[5 rows x 29 columns]
```

3 Calculate annual average output loss

- Consider only the lost output of destroyed capital, not the cost for reconstruction (which would actually produce new jobs)
- $\Delta y(t) = \pi \cdot \Delta k_0 e^{-\lambda t} \Rightarrow \Delta Y = \pi \cdot \Delta k_0 \int_0^\infty e^{-\lambda t} dt = \pi \frac{\Delta k_0}{\lambda}$

[7]:
```
output_loss = macro_inputs.avg_prod_k * quintile_results.dk / quintile_results.
 ↪lambda_h * quintile_results.n
output_loss = output_loss.groupby(['iso3', 'hazard', 'rp', 'income_cat']).sum()
output_loss = average_over_rp(output_loss, protection_=hazard_protection,␣
 ↪zero_rp=2).groupby(['iso3', 'income_cat']).sum()
output_loss
```

[7]:
```
iso3  income_cat
AGO   0.2           0.340277
      0.4           0.716798
      0.6           0.516779
      0.8           0.325207
      1.0           0.874970
                      …
ZWE   0.2           0.058629
```

```
      0.4           0.352763
      0.6           0.374634
      0.8           0.574512
      1.0           1.491346
Name: 0, Length: 660, dtype: float64
```

3.1 Calculate annual average job loss as the ratio of output loss to average worker productivity

[8]:
```
job_loss_quintile = (output_loss / avg_worker_productivity * 100).rename('job␣
↪loss [%]')
job_loss_quintile
```

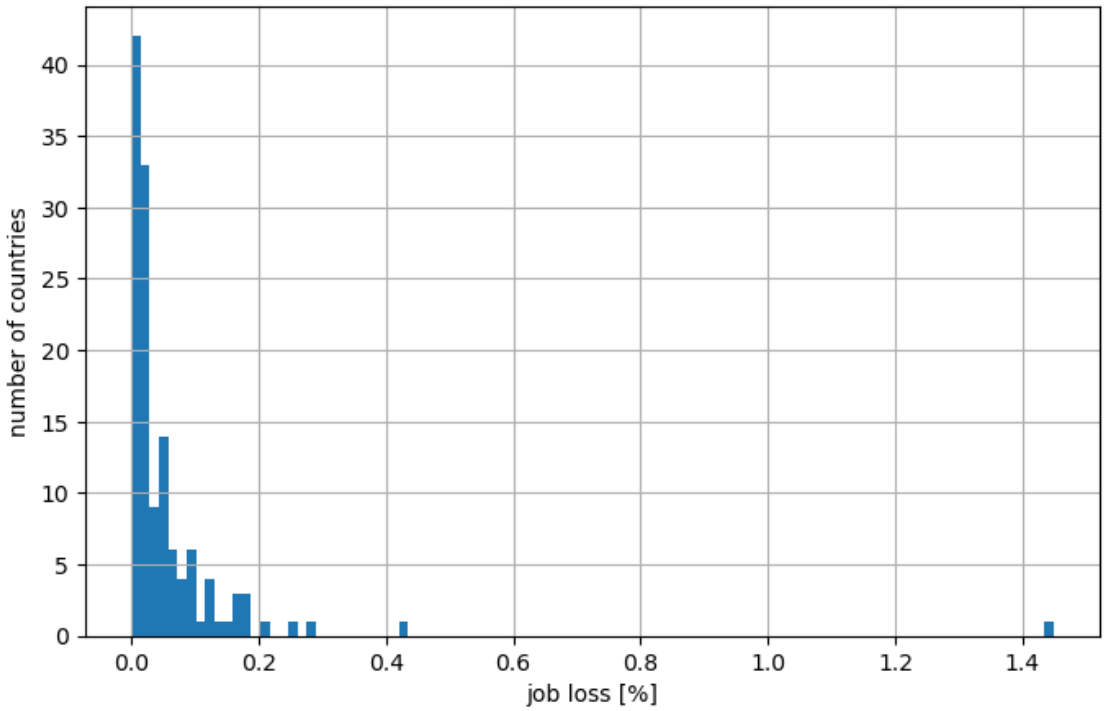
[8]:
```
iso3  income_cat
AGO   0.2           0.023870
      0.4           0.024912
      0.6           0.011067
      0.8           0.004315
      1.0           0.004329
                      …
ZWE   0.2           0.010882
      0.4           0.026365
      0.6           0.019991
      0.8           0.016259
      1.0           0.014964
Name: job loss [%], Length: 660, dtype: float64
```

[9]:
```
job_loss_ctry = job_loss_quintile.groupby('iso3').mean().rename('job loss [%]')
job_loss_ctry.sort_values()[:-5].describe()
```

[9]:
```
count    127.000000
mean       0.041572
std        0.044751
min        0.000442
25%        0.011146
50%        0.023586
75%        0.057331
max        0.188150
Name: job loss [%], dtype: float64
```

[10]:
```
fig, ax = plt.subplots(figsize=(8, 5))
job_loss_ctry.hist(bins=100)
ax.set_xlabel('job loss [%]')
ax.set_ylabel('number of countries')
```

[10]:
```
Text(0, 0.5, 'number of countries')
```



[11]:
```
# load WB map shapes
map_shapes = gpd.read_file("../../05_code/UB-global-socioeconomic-resilience/
 ↪data/WB_shapes/simplified/WB_GAD_ADM0_complete.shp")
adm_0_na_index = map_shapes[map_shapes.ISO_A3.isna()].index
map_shapes.loc[adm_0_na_index, 'ISO_A3'] = [f"XXX-{i}" for i in␣
 ↪range(len(adm_0_na_index))]
map_shapes = map_shapes.rename(columns={'ISO_A3': 'iso3'}).dissolve(by='iso3',␣
 ↪as_index=True)

# plot job loss data
fig, ax = plt.subplots(figsize=(12, 4))
map_shapes.plot(ax=ax, fc='lightgrey')
gpd.GeoDataFrame(pd.merge(job_loss_ctry, map_shapes, left_index=True,␣
 ↪right_index=True)).plot(
    ax=ax,
    column='job loss [%]',
    legend=True,
    scheme='UserDefined',
    classification_kwds={'bins': [.01, .02, .03, .05, .075, .1, .125, .15, .2]},
)
leg = ax.get_legend()
leg.set_bbox_to_anchor((1, 1))
leg.set_loc("upper left")
```

```
leg.set_title("Annual average\njob Loss (%)")
```